REMARKS

Claim Status

Claim 16-35 are pending. The Examiner withdrew Claims 26-35 from further consideration as drawn to non-elected invention. Applicants now cancel Claims 23 and 30-34.

Amendment to the Specification

The paragraph on page 6, lines 17 through 33 is amended to correct an obvious typographical error. One of ordinary skill would appreciate that this paragraph describes the properties of various embodiments of the membranes of the present invention that result from the presence in the membranes of a *polyvinylphosphonic* acid.

Claims Amendment

Claim 16 are amended to recite that the product obtained in step (a) includes at least 10% by weight of vinyl-containing phosphonic acid, as recited on page 27, line 1, of the English translation of the instant application. Claim 16 is further amended to recite that the intrinsic conductivity of the proton-conducting polymer membrane at temperatures of 160°C is at least 0.001 S/cm, as recited on page 33, lines 14-15, of the English translation of the instant application. Claim 16 is still further amended to recite that the product of step (c) is an interpenetrating polymer network (IPN), as disclosed on page 6, lines 17 through 33 of the English translation of the present application.

Additionally, Claim 16 is amended to further clarify that the term "mixing" refers to mixing a polymer and a vinyl-containing phosphonic acid.

Claim 24 is amended to be consistent with the amendments to Claim 16.

Withdrawn Claims 29 and 35 are amended to make them dependent on Claim 16.

Claims 23 and 30-34 are cancelled.

Applicants' Invention

In a preferred embodiment, Applicants' invention is a proton-conducting electrolyte membrane obtained by a method recited in Claim 16, as amended. The steps include mixing a polymer with a vinyl-containing phosphonic acid and polymerizing the

vinyl-containing phosphonic acid present. As a result, an interpenetrating network of polyvinyl-phosphonic acid and the polymer is formed (page 6, line 24, of the English translation of the instant application, as amended). Claim 16, as amended, further defines an electrolyte membrane that formed from a mixture of the polymer and vinyl-containing phosphonic acid that includes at least 10% by weight of vinyl-containing phosphonic acid. The recited process steps permit the final product to possess the intrinsic conductivity of the inventive membrane at 160°C is at least 0.001 S/cm. (See the English translation of the specification as filed: Table 1, page 42; Table 2, page 43; Table 3, page 44; Table 4, page 45; Table 5, page 46.)

The electrolyte membrane so obtained possesses important and unexpected advantages. In particular, an electrolyte membrane defined by Claim 16 exhibits high conductivity over a wide temperature range, including temperatures above water boiling point, when no moisture is present (see the English translation of the instant application, page 6, lines 2-4 and 19-21). Moreover, the electrolyte membranes of Claim 16 possess good mechanical properties that improve their service life (page 6, lines 8-10).

In other words, the process steps recited in the base claims confer unexpected advantages on the proton-conducting electrolyte membrane obtained by the method recited in the base claims that could not have been predicted based on the cited references.

Election/Restriction

The Examiner withdrew Claims 26-35 from further consideration as drawn to non-elected invention. Claims 16-25 were examined. Applicants now amended withdrawn Claims 29 and 35 to make them dependent on pending Claim 16 and to more particularly point out that the inventions defined by Claims 19 and 35 belong in the same group as Claim 16.

Applicants note that the subject matter of Claim 29 is now a membrane-electrode unit containing at least one proton-conducting polymer membrane of Claim 16, while the subject matter of Claim 35 is now a fuel cell containing one or more proton conducting polymer membranes of Claim 16. As such, examination of the subject matter of Claim 16 *includes* examination of the subject matter of Claim 29 and 35, as amended. Accordingly, Applicants

submit that Claims 29 and 35 *have been examined*, and therefore their withdrawal by the Examiner is improper and should be withdrawn.

Claim Objections

The Examiner objected to Claim 16, stating that the phrase "mixing a polymer with vinyl-containing phosphonic acid" is confusing. Applicants amended Claim 16 to recite "mixing a polymer and a vinyl-containing phosphonic acid". Applicants believe that this amendment addresses the Examiner's objection.

Rejection of Claims 16-24 under 35 U.S.C. §102(e) over U.S. 6,607,856 ("Suzuki")

The Examiner rejected Claims 16-25 as being anticipated under 35 U.S.C. §102(e) by Suzuki.

The Examiner stated that Suzuki discloses the preparation of a solid polymer electrolyte membrane in the form of an interpenetrating polymer network (IPN), and that the process of Suzuki, as shown in Figure 9, includes polymerization and/or cross-linking a monomer within the polymer chains of an electrolyte membrane. The Examiner referred to Suzuki's Examples 1, 3 and 5, stating that these examples describe the monomer as a vinylphosphonic acid and the polymer as a polyether sulfone or a polyether ether ketone. The Examiner stated that Suzuki obtained the IPN final product by each of two different approaches: (A) by making a polymer blend by directly mixing polyvinylphosphonic acid with another polymer; and (B) by polymerizing and/or cross-linking a monomer within a polymer. The Examiner referred to FIG. 9 of Suzuki as providing support for approach (B). The Examiner stated that Suzuki explicitly or implicitly anticipates the product of Claim 16.

Claim 16 is now amended to recite that the product obtained in step (a) includes at least 10% by weight of vinyl-containing phosphonic acid and that the intrinsic conductivity of the proton-conducting polymer membrane at temperatures of 160°C is at least 0.001 S/cm. Applicants submit that the membranes of pending Claim 16, as amended, are novel and non-obvious in view of Suzuki because (a) the range of polyvinyl-containing phosphonic acid content in membranes of Claim 16 confers unexpected advantage of high-temperature conductivity onto

Applicants' membranes and (b) Suzuki does not provide any motivation to raise polyvinyl-phosphonic acid content.

Regarding approach (A) of Suzuki, referred to by the Examiner in the Office Action, Applicants note that Examples 1, 3 and 5 of Suzuki do *not* teach interpenetrating polymer network. Suzuki teaches that a first polymer, ethylene-tetrafluoroethylene-graft-polystyrene (ETFE-g-PSt), is doped with a second polymer, *poly*vinylphosphonic acid. The processes of Suzuki's Examples 1, 3 and 5 include a step in which polymeric chains of polyvinylphosphonic acid are mixed with ETFE-g-PSt (see, *e.g.* Example 1, column 9, lines 45-55; Example 3, column 11, lines 64-65[1]; Example 5, column 12, lines 51-53).

Although Suzuki does use the term "interpenetrating polymer network", one of ordinary skill in the art of polymer science will appreciate that forming an interpenetrating network from two different polymers runs against steric, electrostatic and other physical limitations inherent in trying to thread polymer chains through one another. Because Applicants' Claim 16 is produced by polymerizing a vinylphosphonic acid monomer *in situ*, within a pre-existing polymer, the product produced by the process of Claim 16 possesses the properties of an IPN. This feature is now expressly recited in Claim 16. Thus, Claim 16 as amended is novel over Suzuki.

Regarding approach (B) of Suzuki, referred to by the Examiner in the Office Action, Applicants note that FIG. 9 of Suzuki refers to Examples 18 and 19 (see Suzuki, column 30, lines 55-62). Examples 18 and 19 describe a method of preparation a polymer that includes immersing a membrane into a mixture of vinylphosphonic and divinylbenzenemonosulfonic acid, followed by polymerizing the vinyl-containing acids. However, phosphonic acid content in Example 18 is 9% by weight *before* washing and is 7% by weight after washing (col. 29, ll. 50 and 55). In Example 19, phosphonic acid content is even lower: 5% by weight before washing and 4% by weight after washing (col. 30, ll. 5 and 11).

Applicants amended Claim 16 to recite that the product obtained in step (a) includes at least 10% by weight of polyvinyl-containing phosphonic acid. This is a larger amount of the starting ingredient that in Suzuki. Accordingly, Applicants submit that the final product

---

[1] Applicants note that there appears to be a typographical error in Suzuki, at column 11, line 64. It would appear that the text should read that "5% DMF of poly vinyl phosphonic acid used in Example 1 was blended with 5% DMF sulfonated-PES".

prepared by the steps recited in Claim 16 will also have higher phosphonic acid content that the product of Suzuki.

Furthermore, because a membrane claimed in Applicants' Claim 16 is produced so that the pre-polymerized mixture obtained in step (a) includes at least 10% by weight of vinyl-containing phosphonic acid, the Applicants' membranes possesses conductivity of at least 0.001 S/cm at 160 °C. This property is neither disclosed nor suggested in Suzuki.

To further support the assertion that the membranes of Suzuki do not possess the conductivity comparable to the membranes of Applicants' Claim 16, Applicants submit herewith a Declaration by Dr. Schmidt Under 37 C.F.R. §1.132 (the "Declaration")[2]. The Declaration describes experiments that show that a proton-conducting membrane prepared by the method similar to that of Applicants' Claim 16, with the difference being that the polymer film used in step (a) was doped with only 9% by weight of polyvinyl-containing phosphonic acid, resulting in 7% by weight final doping ratio, possesses conductivity at 160 °C that is less than 0.00001 S/cm (10^{-5} S/cm). This value is *100 times* lower than the value recited in Applicants' Claim 16.

The Declaration, thus, demonstrates that where a membrane is prepared according to Applicants' methods, but such a membrane is only doped by a polyvinyl-containing phosphonic acid at the level lower than that recited in Claim 16, as amended, this membrane does not possess an advantageous property of high-temperature conductivity.

In contrast, and as demonstrated by Examples 1-27 on pages 40-50 of the specification as filed, the Applicants' membranes possess high-temperature conductivity that is significantly above 0.001 S/cm.

Applicants further submit Suzuki does not provide any reason for one of ordinary skill in the art to modify his membranes by incorporating the phosphonic acid at the concentration recited by applicants.

In the membranes of Suzuki, the phosphonic groups introduced by incorporating a polyvinyl-containing phosphonic acid serve a purpose different from Applicants'. Whereas in Applicants' membranes incorporation of a phosphonic acid improves high-temperature conductivity, in membranes of Suzuki phosphonic acid groups serve as metal chelator groups

[2] Applicants enclose an unsigned copy of the Declaration. The Declaration signed by Dr. Schmidt will be filed by a supplementary response as soon as it is available.

(see Abstract and col. 4, ll. 43-51). Chelating metals, such as Fe^{2+} or Cu^{2+}, helps improve the service life of the membrane by inhibiting harmful peroxide-forming reaction (col. 1, ll. 38-48 and col. 4, ll. 26-36). Furthermore, Suzuki is silent on the contribution to conductivity by the phosphonic acid and does not teach that raising the phosphonic acid content is beneficial for any other purpose. Higher concentration of phosphonic acid is not needed for chelating metals. Accordingly, based on Suzuki, one of ordinary skill in the art would not be motivated to increase the content of a polyvinyl-containing phosphonic acid to the levels recited in Applicants' Claim 13, as amended.

Applicants note that the materials of Suzuki belong to a class of proton-conductive materials different from those claimed by Applicants. The materials of Suzuki require the presence of water/moisture because the sulfonic acid moieties ($-SO_3H$) are employed for conductivity and, as such, are "low temperature polymer electrolyte materials", which operate below 100°C and in the presence of water/moisture. At higher temperature, for example, at 160°C, no water/moisture is present, and the sulfonic acid moieties will no longer contribute to conductivity at this temperature. Conversely, the Applicants' materials utilize a different conductivity mechanism (so called "Grotthus Mechanism") and, therefore, are "high temperature polymer electrolytes", capable of operating above 100°C.

In view of the above, the membranes of Applicants' Claim 16, as amended, and claims dependent thereon are not only novel in view of Suzuki but are also non-obvious.

Reconsideration and withdrawal of the rejection are respectfully requested.

Rejection of Claim 25 Under 35 U.S.C. §103(a)

Claim 25 stand rejected as being obvious under 35 U.S.C. §103(a) over Suzuki in view of US 2003/0031909 ("Gascoyne"). The Examiner stated that Suzuki is silent on using a proton conducting membrane comprising a layer containing a catalytically active component. The Examiner stated that Gascoyne explicitly teaches such a subject matter. The Examiner stated that because the cited references all relate to the filed of proton-conducting polymer membranes, one of ordinary skill would find it obvious to modify the membranes of Suzuki with a catalytically active component of Gascoyne.

Without acquiescing to the merits of the Examiner's argument, Applicants submit that Claim 25 is not obvious over the combination of Suzuki and Gascoyne as a claim dependent on Claim 16, as amended, which, as argued above, is patentable over Suzuki. Furthermore Applicants submit that Gascoyne does not remedy the failure of Suzuki to teach a membrane that is produced so that the pre-polymerized mixture includes at least 10% by weight of vinyl-containing phosphonic acid. Since, as Applicants argued above, such a membrane possesses an unexpectedly advantageous property of conductivity of at least 0.001 S/cm at 160 °C, Claim 16, as amended, and therefore dependent Claim 25, are both non-obvious over the combination of Suzuki and Gascoyne.

Reconsideration and withdrawal are respectfully requested.

CONCLUSION

In view of the above remarks, it is believed that all claims are in condition for allowance, and it is respectfully requested that the application be passed to issue. If the Examiner feels that a telephone conference would expedite prosecution of this case, the Examiner is invited to call the undersigned.

Respectfully submitted,

HAMILTON, BROOK, SMITH & REYNOLDS, P.C.

By Alexander Akhiezer

Alexander Akhiezer
Registration No. 54,617
Telephone: (978) 341-0036
Facsimile: (978) 341-0136

Concord, MA 01742-9133
Dated: 4/13/09